

WHAT IS CLAIMED IS:

- 1 1. A hydraulic control apparatus for a vehicle having an  
2 engine, the hydraulic control apparatus comprising:
  - 3 a belt-drive continuously variable transmission (CVT)  
4 including a primary pulley and a secondary pulley, each of  
5 the primary and secondary pulleys having a cylinder chamber  
6 to which an oil pressure is supplied and defining a groove  
7 variable in width corresponding to the oil pressure, and a  
8 belt engaged with the groove to transmit rotation of the  
9 primary pulley to the secondary pulley, the belt-drive CVT  
10 being operative to continuously vary a transmission ratio by  
11 changing the width of the groove;
  - 12 an oil pressure source operative to produce an oil  
13 pressure supplied to the belt-drive CVT, the oil pressure  
14 source being adapted to be driven by the engine;
  - 15 a pressure regulator valve operative to regulate the oil  
16 pressure produced by the oil pressure source;
  - 17 a controller programmed to develop a transmission  
18 control signal, the transmission control signal including a  
19 high speed transmission control signal for changing the  
20 transmission ratio to a high speed side and a low speed  
21 transmission control signal for changing the transmission  
22 ratio to a low speed side;
  - 23 a transmission actuator operative to be driven based on  
24 the transmission control signal;
  - 25 a first oil passage for supplying the oil pressure  
26 regulated by the pressure regulator valve;
  - 27 a second oil passage for supplying the oil pressure  
28 regulated to the cylinder chamber of the primary pulley and  
29 draining the oil pressure from the cylinder chamber of the  
30 primary pulley;
  - 31 a third oil passage for draining the oil pressure within  
32 the cylinder chamber of the primary pulley;

33        a fourth oil passage downstream of the pressure  
34 regulator valve; and

35        a transmission control valve operative to be actuated by  
36 the transmission actuator for controlling the oil pressure  
37 within the cylinder chamber of the primary pulley, the  
38 transmission control valve including a first port  
39 communicated with the first oil passage, a second port  
40 communicated with the second oil passage, a third port  
41 communicated with the third oil passage, and a spool having  
42 a block position where fluid communication between the first,  
43 second and third ports is prevented, a high speed side  
44 transmission position where the first port is fluidly  
45 communicated with the second port when the transmission  
46 actuator is driven in response to the high speed  
47 transmission control signal, and a low speed side  
48 transmission position where the second port is fluidly  
49 communicated with the third port when the transmission  
50 actuator is driven in response to the low speed transmission  
51 control signal, the spool cooperating with the transmission  
52 actuator and the primary pulley to form a mechanical  
53 feedback mechanism for returning the spool to the block  
54 position in response to change in the width of the groove of  
55 the primary pulley,

56        wherein the third oil passage is connected with the  
57 fourth oil passage to supply an oil pressure to the cylinder  
58 chamber of the primary pulley and establish a minimum oil  
59 pressure required for clamping the belt depending on  
60 reduction of the oil pressure within the cylinder chamber of  
61 the primary pulley.

1        2. The hydraulic control apparatus as claimed in claim 1,  
2 wherein the vehicle includes a torque converter disposed  
3 between the engine and the belt-drive CVT so as to increase

4      torque of the engine, a lockup clutch allowing direct  
5      coupling of the engine and the belt-drive CVT, an oil cooler,  
6      and lubrication parts, the hydraulic control apparatus  
7      further comprising:

8              a torque converter regulator valve disposed downstream  
9      of the pressure regulator valve, the torque converter  
10     regulator valve being operative to produce a torque  
11     converter pressure and a lockup clutch applying pressure and  
12     a lockup clutch releasing pressure to be supplied to the  
13     lockup clutch;

14              wherein the fourth oil passage is a cooler-lubrication  
15     oil supply passage for supplying an oil pressure drained  
16     from the torque converter regulator valve to the oil cooler  
17     and the lubrication parts.

1      3. The hydraulic control apparatus as claimed in claim 1,  
2      wherein the vehicle includes a start clutch operative to be  
3      applied when the vehicle is started, a torque converter  
4      disposed between the engine and the belt-drive CVT so as to  
5      increase torque of the engine, and a lockup clutch allowing  
6      direct coupling of the engine and the belt-drive CVT, the  
7      hydraulic control apparatus further comprising:

8              a clutch regulator valve operative to regulate an oil  
9      pressure drained from the pressure regulator valve and  
10     produce a start clutch applying pressure to be supplied to  
11     the start clutch; and

12              a torque converter regulator valve operative to  
13      regulate an oil pressure drained from the clutch regulator  
14     valve and produce a torque converter pressure and a lockup  
15     clutch applying pressure and a lockup clutch releasing  
16     pressure to be supplied to the lockup clutch;

17              wherein the fourth oil passage is a lockup clutch oil  
18     supply passage for supplying the lockup clutch applying

19 pressure and the lockup clutch releasing pressure to the  
20 lockup clutch.

1 4. The hydraulic control apparatus as claimed in claim 3,  
2 wherein the lockup clutch oil supply passage is communicated  
3 with an oil passage connecting the clutch regulator valve  
4 and the torque converter regulator valve.

1 5. The hydraulic control apparatus as claimed in claim 1,  
2 wherein the vehicle includes a start clutch operative to be  
3 applied when the vehicle is started, and a lockup clutch  
4 allowing direct coupling of the engine and the belt-drive  
5 CVT, the hydraulic control apparatus further comprising:

6 a clutch regulator valve operative to regulate an oil  
7 pressure drained from the pressure regulator valve and  
8 produce a start clutch applying pressure to be supplied to  
9 the start clutch;

10 wherein the fourth oil passage is a start clutch oil  
11 supply passage for supplying the start clutch applying  
12 pressure to the start clutch.

1 6. The hydraulic control apparatus as claimed in claim 5,  
2 wherein the start clutch oil supply passage is communicated  
3 with an oil passage connecting the pressure regulator valve  
4 and the clutch regulator valve.

1 7. The hydraulic control apparatus as claimed in claim 6,  
2 wherein the oil passage connecting the pressure regulator  
3 valve and the clutch regulator valve is communicated with  
4 the first oil passage.

1 8. The hydraulic control apparatus as claimed in claim 1,  
2 wherein the first oil passage is communicated with an oil

3   passage connecting the oil pressure source and the pressure  
4   regulator valve to supply the oil pressure produced by the  
5   oil pressure source to the pressure regulator valve.

1   9.   The hydraulic control apparatus as claimed in claim 1,  
2   further comprising a link connecting the transmission  
3   actuator, the spool and the primary pulley, the link forming  
4   the mechanical feedback mechanism together with the  
5   transmission actuator, the spool and the primary pulley.

1   10.   The hydraulic control apparatus as claimed in claim 1,  
2   wherein the transmission actuator is a stepping motor.